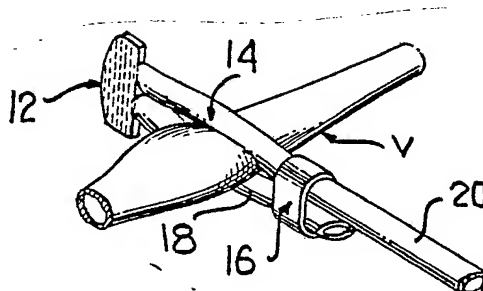




## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

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<b>(21) International Application Number:</b> PCT/US83/00411 <b>(22) International Filing Date:</b> 24 March 1983 (24.03.83) <b>(31) Priority Application Number:</b> 361,386 <b>(32) Priority Date:</b> 24 March 1982 (24.03.82) <b>(33) Priority Country:</b> US  <b>(71)(72) Applicants and Inventors:</b> ROZARIO, Rodney, A. [IN/US]; 836 Essex Street, Bangor, MN 04401 (US). DUJOVNY, Manuel [US/US]; Henry Ford Hospital, Dept. of Neurosurgery, 2799 West Grand Blvd., Detroit, MI 48202 (US).  <b>(74) Agent:</b> MEERKREEBS, Samuel; 5509 Greystone Street, Chevy Chase, MD 20815 (US).		<b>(81) Designated States:</b> AT (European patent), AU, BE (European patent), BR, CH (European patent), DE (European patent), DK, FR (European patent), GB (European patent), JP, LU (European patent), NL (European patent), SE (European patent).  <b>Published</b> <i>With international search report.</i>

**(54) Title:** TEMPORARY MICROVASCULAR OCCLUDER



**(57) Abstract**

A microvascular occluder (10) produced from a suitable plastic, colored and/or transparent; including a pair of juxtapositionable legs (18, 20) secured together in clamping relation on a blood vessel between a base (12) and a cuff (16) slidable over the legs, in which the cuff is retained on the occluder, and in which an indicia scale (34) can be incorporated on one or both of the legs, and in which the cuff can contain magnetically-attractive material and can be moved magnetically; and in which the occluder is readily sterilized through conventional procedures, and inexpensive to manufacture so that it is readily expendable after usage. An occluder holder comprising a tubular sleeve (40) having a longitudinal slot (42) for holding two occluders in spaced straddling relation on a blood vessel during microvascular anastomosis.

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DescriptionTemporary Microvascular OccluderTechnical Field

The present invention relates generally to  
5 medical and surgical clamps, and more particularly  
relates to a device for temporarily occluding small  
vessels during microvascular surgery. Still more  
particularly, the present invention relates to a  
relatively minute occluder of the character mentioned  
10 in which endothelial damage is substantially minimized;  
if not eliminated, and thus, thrombosis and anastomosis  
failure is minimized in a technically adequate procedure.

Background Art

When a surgeon is engaged in a surgical  
15 procedure requiring occlusion of small vessels, it is  
critical that the device be of a size so as not to  
impair visual and physical access to the area of the  
vessel being operated on, and endothelial damage be  
minimized to avoid thrombosis and anastomosis failure.

20 A wide variety of miniature aneurysm clips,  
a microtourniquet and microblock have been proposed  
in the past; see the "References" below. All of  
these prior art devices, when observed with a scanning  
electron microscope, appear to inflict varying degrees  
25 of endothelial damage.

In addition to the devices of the "References";  
see Appendix I, a vessel ligatures are disclosed in  
the patents to Flores 3,665,926, Ferrier, 3,507,270,  
Ferguson 3,887,434 and Jones 4,248,224.

30 None of the prior art devices afford the  
degree of soft pressure control afforded by the  
invention during microvascular anastomosis.

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Disclosure of Invention

The present invention solves many of the problems and shortcomings of the prior art in a simple and inexpensive manner with a device that is  
5 easy to construct, simple in operation and use, readily sterilized, and of minimal expense.

More particularly, the occluder of the present invention comprises three components, i.e., a main stem, base and cuff. The main transparent stem  
10 comprises a long and short arm terminally connected in hinged, integral relation as the base with the cuff being circumposed and slidable on the long arm and prevented from becoming separated therefrom by a terminal stop. The short arm has a beveled free end  
15 facilitating the movement of the cuff thereover to clamp a blood vessel between the arms, and the arms are produced from tubular, polyethelene tubing, or the like, so that cuff pressure is gradually or progressively applied to a clamped blood vessel.

20 In addition to the general aspects of the invention, features such as magnetically moving the cuff into and out of a clamping position, the use of different materials or colors, as well as different tub (arm) cross sections, and/or reinforcements in  
25 the clamp arms are all within the scope of the invention.

Brief Description of Drawings

These together with other objects and the nature of the invention will become apparent from the following detailed description, taken in conjunction  
30 with the drawing, forming a part thereof, in which like parts are identified by like reference numerals, wherein:

Fig. 1 is a side elevational view of the occluder of the invention on an enlarged scale;

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Figs. 2 and 3 are enlarged, fragmentary elevations of the portions within the phantom-line ovals identified at Fig. 2 and Fig. 3 on Fig. 1;

Fig. 4 is a bottom plan view of Fig. 2 looking in the direction of line 4-4 of Fig. 2;

Fig. 5 is a sectional view taken on line 5-5 of Fig. 2;

Fig. 6 is a fragmentary perspective view of the container in an operative position on a blood vessel;

Fig. 7 is a view similar to Fig. 2, and showing an alternate embodiment;

Fig. 8 is a graphic illustration of a test of the invention plotting arterial pressure (mmHg) or Clamp Force (grams) (based upon 0.6 sq. mm interior occlusion area) in relation to cuff-to-base L (mm); and

Fig. 9 is a perspective view of a holding means for orienting a pair of the occluders when straddling a vein section.

#### Best Mode for Carrying Out the Invention

Referring to the drawing in detail, and first considering Fig. 1-5, the microvascular occluder is indicated generally at 10 and comprises three components, a base 12, a stem 14 and cuff 16.

The components are produced from any suitable plastic material such as rubber, silastics, polyethylene, polystyrene, etc., and the working model tested, was produced from a flexible, polyethylene tubing. Construction will be accomplished through conventional molding procedures, all within the skill of the art.

The stem 14 includes a long arm 18 and a short arm 20, each being terminally secured at their adjacent ends 22 and 24, respectively; see Fig. 2, to

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the base 12 by welding or fusing, or the like, whereby the base and terminal ends of the arms are integrated as indicated at 26. The outer or free end 28 of the short arm 20 is beveled away from the end as indicated at 30 and this facilitates movement of cuff 16 to the phantom-line position in Fig. 2 after the short arm 20 has been pivoted into substantial parallel relation to arm 18, as illustrated in Figs. 2 and 6, for example.

10           The cuff 16 comprises a suitably diametered tube section, and will be moved manually into clamping position. Although manual movement is accomplished using forceps or the like, alternatively, the cuff 16 can be impregnated with a magnetically-attractive material, i.e., such as ferrous oxide, or the like, and can be incrementally moved in clamped relation on the arms 18 and 20 by a suitable magnet means 31.

15           The outer or free end of the long arm 18 is terminally upset or flattened to form a stop or abutment 32 which will prevent inadvertent loss of cuff 16. In regard to loss of the cuff, to facilitate its location and to properly position the same in operative relation on the arms as will be described below, the entire occluder, may be produced in various colors to assist the surgeon and medical assistants in observing and locating the occluder during procedures.

20           The base 12 acts as the point of flexion between the two arms of the stem and the final shape of the base; note it is flattened as seen in Fig. 4; is produced by the application of heat and pressure to produce the fusing.

25           The cuff 16 is approximately 2 mm long, i.e., about 1/16 inch long, being produced from a segment of polyethylene tubing with an outer diameter of around 1.7 mm and an inner diameter of about 1.2 mm,

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which fits snugly, but yet slides over both arms of the stem during application. The arms 18 and 20 are produced from polyethylene tubing having an outer diameter of around 0.6 mm and an inner diameter of about 0.27 mm. The long arm is about 6 cm long, but can be varies in length, and the short arm 20 can be of different lengths, being shown as about 10 mm in Fig. 7, and the scale indicia 34 can be applied to the short (or long) arm 18' as shown in Fig. 7. The dimensions are those of the operative phototype tested and are intended to be illustrative and not restrictive.

Before describing actual tests and operation, it is pointed out that the arms of the disclosed stem provide sufficient clamping and elasticity during release; however, in the event greater resiliency is desired, a steel wire 36, for example can be embedded, in the arm 18' and 20' of the embodiment 10' of Fig. 7.

The selection of tubular arms produced an unusual soft and gradual application of pressure, and cushioning to the vessels being occluded, which was surprisingly unexpected. Although a circular cross sectioned tubing was utilized when producing the prototype, other cross sectioned tubings are within the purview of the invention, i.e., polygonal (triangular, square, rectangular) as well as oval, and even solid cross sections, of compressibility comparable to tubular arms, are contemplated to be within the scope of the invention.

#### APPLICATION TECHNIQUE

Referring to Fig. 6, after the standard preparation of a vessel, for microvascular anastomosis, the occluder 10 is passed under the vessel V with the

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short arm 20, uppermost. Arms 18 and 20 are brought together gently and the cuff is placed in position, as shown in Fig. 2. The distance between the base and the cuff can be varied. When blanching of the vessel between the two arms and cessation of transmitted pulsation is seen, occlusion has been effected. Incorrect positioning results in slippage of the occluder with each arterial pulsation.

The advantage of the long arm is that it permits rotation of the vessel into the optimal position during anastomosis. Upon completion of the procedure, the cuff can be withdrawn partially while the vessel is still in the occluder. This permits control of blood flow through the anastomosis, so that the suture line can be observed for signs of potential leakage.

#### MECHANICAL EVALUATION (Fig. 8)

The following experiment was undertaken to test the mechanical effectiveness of the occluder. An 8 mm segment of carotid artery, measuring 1 mm diameter, was resected from a 450-g Sprague-Dawley rat and was washed free of all blood elements with Ringer's lactate solution. This distal end of a polyethylene tube (PE 190) was placed under an operating microscope, and two shallow annular grooves were cut adjacent to one another. One end of the arterial segment was then placed over the tube for a distance of 3 mm and was secured in place with two 7.0 silk ties, with the precut groove used to anchor the sutures. The proximal end of the tube was connected to a Statham transducer (Statham Instruments Division, Gould, Inc., Oxnard, California) and a Grass polygraph (Grass Instrument Co., Quincy, Massachusetts). The system was filled with normal saline, free of air bubbles and was zeroed for pressure recording.

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For the purpose of the experiment, an occluder with short arm 14 mm long was constructed to permit recording of applications with a cuff-to-base distance between 2 and 10 mm. With the operating  
5 microscope at 25 x magnification, the occluder was placed on the distal end of the arterial segment. The first application was at a base-to-cuff distance of 10 mm. The pressure in the system was increased gradually by injecting normal saline into the transducer  
10 with a tuberculin syringe. Through the microscope, the point at which either slippage of the occluder or saline leakage was first observed was noted, and the pressure was recorded. Further pressure readings were obtained at cuff-to-base distances of 8, 6, 5,  
15 4, 3, and 2 mm, and a graph was constructed with these measurements.

To obtain an estimate of the "clamp force" exerted by the occluder, we used the following method to evaluate the occluding area during the application.  
20 Evans blue dye was injected into the transducer with the occluder applied at a cuff-to-base distance of 4 mm and a pressure of 100 mm Hg. By diffusion, the dye traveled distally and stained the artery proximal to the occluder. A dilute solution of dye was also  
25 placed in the open end of the artery. This stained the artery distal to the occluder. With the occluder still applied, the segment of artery 1 mm distal and proximal on either side of the occluder was resected and washed in saline. The occluder was then removed  
30 and the artery was opened. The unstained area was measured under the microscope, and a segment 1.5 mm long and 0.4 mm wide, representing an area of  $0.6 \text{ mm}^2$ , was obtained. Using the measurements of arterial pressure and the occluding area, we calculated the  
35 clamp force exerted at the various application points.

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Scanning electron microscope evaluation

Thirty Sprague-Dawley rats weighing between 350 and 500 g were divided randomly into a control group of 10 animals and an experimental group of 20 animals. The rats were anesthetized with pentobarbital (40 mg/kg intraperitoneally) followed by the subcutaneous administration of 0.4 mg of atropine. Both carotid arteries were dissected and prepared for application of the occluder using the operating microscope.

In the 10 control rats, the occluder was placed on the right and left carotid arteries, but occlusion was not performed. The right carotid arteries were recovered at 75 minutes and the left carotid arteries at 135 minutes. The arteries were excised under the operating microscope using 25 x magnification, opened longitudinally, and washed gently with Ringer's lactate solution. The flattened arteries were then fixed with 2% buffered glutaraldehyde and prepared for scanning electron microscopy. The endothelial surface of the specimens were examined at 40X to 16,000X using an AMR scanning electron microscope (Advanced Metal Research, Burlington, Massachusetts).

In the experimental group, the occluder was placed on the carotid arteries, and the cuff-to-base distance was adjusted to the point at which blanching of the vessel was observed between the blades of the occluder and arterial pulsations were dampened. The occluder was applied for 1 hour to the right carotid arteries and 2 hours to the left carotid arteries. Before recovery of the specimens, blood flow was restored for 15 minutes. The arteries were ligated both proximal and distal to the occluded area, excised, and prepared for scanning electron microscopy in the same manner as for the control group. The endothelial

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alterations were assessed by the classification of Dujovny et al. (2).

## RESULTS

### Mechanical Evaluation

5           The occluder was effective in preventing  
the flow through a wide range of pressures (80 to 375  
mm Hg) that varied directly with the base-to-cuff  
distance (2 to 10 mm). The clamp force calculated  
was based on the occlusive area of  $0.6 \text{ mm}^2$ . These  
10 findings were compatible with our previous measurement  
for minimal occlusive force (3).<sup>4</sup>

### Results of Scanning Electron Microscopy

15           The 10 control specimens showed a uniform  
architecture of fine longitudinal ridges and folds  
about 15 pm wide. Their smooth undulations comprised  
a normal pattern.

          The experimental specimens occluded for 1  
hour with a temporary vascular occluder presented  
endothelial changes, in the "corner-mirror" configura-  
20 tion (3). Varying degrees of endothelial changes,  
ranging from relatively mild flattening to moderate  
flattening, were found in all experimental specimens.  
Endothelial ridge or fibrin, platelet, or red blood  
cell deposits were observed in any experimental  
25 specimens (Fig. 3). Specimens recovered after 1 hour  
showed milder endothelial changes than did those  
recovered 2 hours after application of the occluder.  
No thrombus formation was observed at the site of  
occlusion in any of the specimens (Fig. 4).

## SUMMARY

With its rounded contour flexibility, the  
present occluder causes a minimal degree of endothelial

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damage, even after 2 hours of application, and the pliable tubing allows gentler contact with the vessel than that occurring with conventional rigid metallic clips. The transparency, the large force spectrum, and the ability to observe directly the blanching and cessation of blood flow are other factors of efficacy and safety. Also, the occluder is smaller than any conventional temporary clip, thus enlarging the operative field. Moreover, the fact that the occluder is perfectly smooth, with no sharp edges, precludes the hazard of suture entanglement.

We have found, using the scanning electron microscope, that the blood products that tend to adhere after the use of either the occluder or a microclip are difficult to remove even with ultrasonic cleaning. Ideally, therefore, only one application per clinical case is advisable. However, the economics of using the microclip on a disposable basis make it a very expensive surgical item.

The microvascular occluder has been used widely in experimental animal anastomoses ranging in vessel size from 0.75 to 2.8 mm in rat, rabbit, guinea pig and dog microvessels. The occluder has also been used clinically in the performance of a superficial temporal artery to middle cerebral artery bypass graft, where it was found to be entirely adequate in maintaining occlusion of the cortical artery.

Although the occluder is a relatively simple device, the principle of using a soft material and a system that allows adjustment of the occlusive force on an individual basis has made the microvascular occluder a versatile and reliable surgical tool. The ability to visualize the cessation of blood flow, the large force spectrum, and the lower potential for the

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development of vascular thrombosis open a new dimension in temporary vascular occlusion.

Referring to Fig. 9, a holder 38 comprises means for orienting a pair of occluders 10 in longitudinally spaced relation along the length of a vessel section. The holder 38 comprises a tubular sleeve 40, open at opposite ends and having a longitudinal slit, or slot 42, end-to-end, i.e., communicating with the open ends. The occluders 10 have the bases 12 thereof, inserted into the open ends of the holder 38, and the arms thereof project in spaced parallel relation from the holder. The clamping cuff of the occluders are tightened in the manner described above, and because of the relatively small size, the holder is a novel adjunct to the novel occluders per se.

The occluder and/or holder heretofore described, are of a material readily adapted for sterilization in an atmosphere of ethylene oxide using conventional, operating room sterilization procedures and techniques. Additionally, because the device is conducive to Mass-Manufacture from relatively inexpensive materials, it lends itself to ready use and adaption.

As various changes could be made without departing from the scope of the invention, it is intended that all matters contained in the above description or shown in the accompanying drawing shall be interpreted as illustrative and not in a limiting sense, the invention being defined in the appended claims.

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Claims

1. A microvascular occluder comprising a base integral with a stem, said stem comprising a pair of legs projecting from said base, one of said legs being shorter than the other and having a free end; and
- 5       cuff means on said other leg and slidable over said legs in unison for capturing a blood vessel between said cuff means and said base and occluding the passage of blood therethrough.
- 10       2. The structure claimed in claim 1 in which said other leg has stop means thereon for capturing the cuff means thereon.
- 15       3. The structure as claimed in claim 1 in which said legs comprise tubular elements.
4. The structure as claimed in claim 1 in which the base and legs are fused together as an integral unit.
- 20       5. The structure as claimed in claim 1 in which said cuff means includes a magnetically attractive material whereby the cuff means is subject to movement through movement of a magnet and magnetic forces.
6. The structure as claimed in claim 1 in which said occluder comprises a plastic material
- 25       through which blood can be observed.
7. The structure as claimed in claim 1 in which at least one of said legs includes indica means therealong.
- 30       8. The structure as claimed in claim 1 including resilient means embedded in said legs for supplying increased rigidity and resilience to said legs.
- 35       9. The structure as claimed in claim 3 in which said tubular elements have a circular cross section.

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10. The structure as claimed in claim 1 in which said shorter leg is terminally beveled at its free end for facilitating sliding of said cuff means thereover.

5 11. The structure as claimed in claim 1 in which said arms are tubular sleeves having an inner diameter of 0.27 mm and an outer diameter of 0.6 mm, said cuff means comprising a tubular element having an outer diameter of 1.7 mm and an inner diameter of  
10 1.2 mm, said cuff means being slidable over the two legs when the legs are in juxtaposition and fitting snugly in circumsposed relation thereabout.

12. A holder for microvascular occluders having an enlarged base means and a stem projecting  
15 therefrom, said holder comprising an elongated element open at least one end, and an elongated slot extending longitudinally along said element and communicating with said one open end whereby the base of a micro-  
20 vascular occluder can be slid through said one open and into said slot with the stem projecting substantially normal from said elongated element.

13. The structure as claimed in claim 12 in which said elongated element comprises a tubular sleeve.

25 14. The structure as claimed in claim 13 in which said tubular sleeve is open at both ends, and said slot extends end-for-end through, and communicates with, said open ends.

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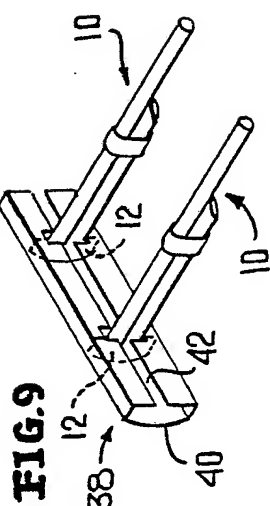


FIG. 1

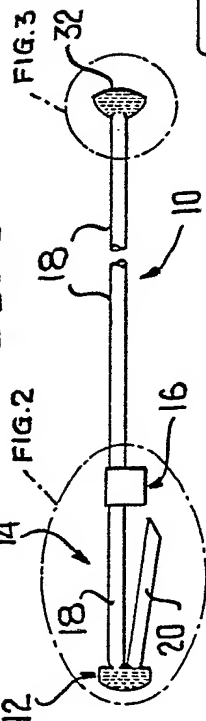


FIG. 2

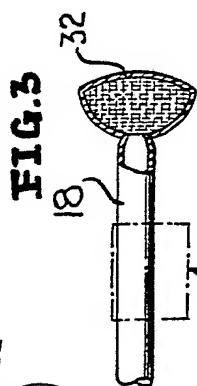


FIG. 3

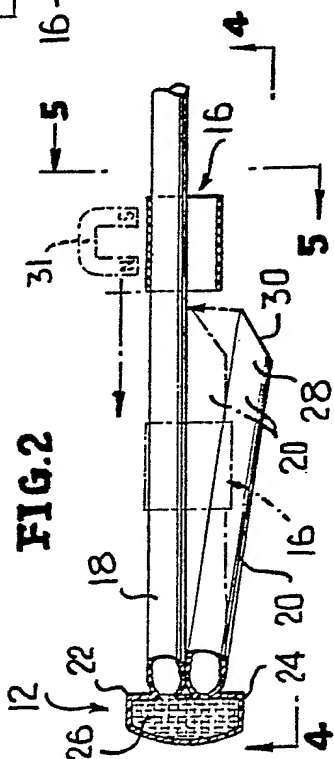


FIG. 4

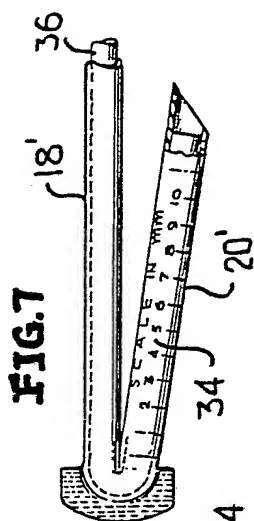


FIG. 5

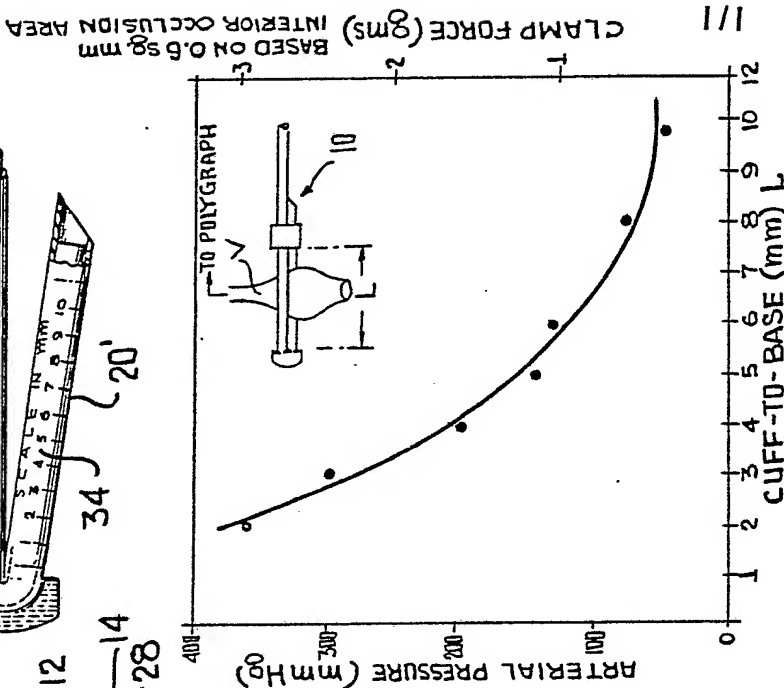


FIG. 6

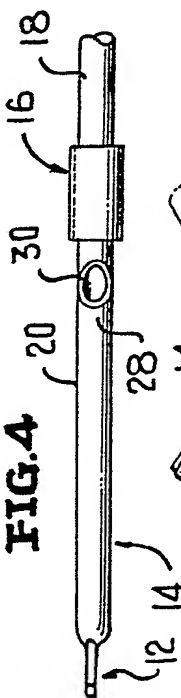


FIG. 7

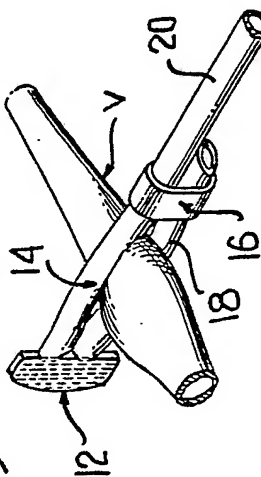


FIG. 8

# INTERNATIONAL SEARCH REPORT

International Application No. PCT/US83/00411

<b>I. CLASSIFICATION OF SUBJECT MATTER</b> (If several classification symbols apply, indicate all) <sup>1</sup> According to International Patent Classification (IPC) or to both National Classification and IPC INT. CL. 3 A61B 17/12 U.S. Cl. 128/325,346																																			
<b>II. FIELDS SEARCHED</b> <div style="text-align: center; border-top: 1px solid black; border-bottom: 1px solid black; margin: 5px 0;">Minimum Documentation Searched <sup>4</sup></div> <table style="width: 100%; border-collapse: collapse;"> <tr> <th style="width: 25%; border-bottom: 1px solid black;">Classification System</th> <th style="border-bottom: 1px solid black;">Classification Symbols</th> </tr> <tr> <td style="border-right: 1px solid black; padding: 5px; vertical-align: top;">U.S.</td> <td style="padding: 5px; vertical-align: top;">128/325,346, 1.3; 251/9.10; 24/30.5L, 251,260, DIG. 8, DIG. 9</td> </tr> </table> <div style="text-align: center; border-top: 1px solid black; border-bottom: 1px solid black; margin: 5px 0;">Documentation Searched other than Minimum Documentation to the extent that such Documents are included in the Fields Searched <sup>5</sup></div>			Classification System	Classification Symbols	U.S.	128/325,346, 1.3; 251/9.10; 24/30.5L, 251,260, DIG. 8, DIG. 9																													
Classification System	Classification Symbols																																		
U.S.	128/325,346, 1.3; 251/9.10; 24/30.5L, 251,260, DIG. 8, DIG. 9																																		
<b>III. DOCUMENTS CONSIDERED TO BE RELEVANT</b> <sup>14</sup> <table style="width: 100%; border-collapse: collapse;"> <tr> <th style="width: 10%; border-bottom: 1px solid black;">Category <sup>6</sup></th> <th style="border-bottom: 1px solid black;">Citation of Document, <sup>16</sup> with indication, where appropriate, of the relevant passages <sup>17</sup></th> <th style="width: 20%; border-bottom: 1px solid black;">Relevant to Claim No. <sup>18</sup></th> </tr> <tr> <td style="border-right: 1px solid black; padding: 5px; vertical-align: top;">Y</td> <td style="border-right: 1px solid black; padding: 5px; vertical-align: top;">US, A 1,352,978 14 September 1920 LANTIERI ET AL</td> <td style="padding: 5px; vertical-align: top;">1-4,8,9-11</td> </tr> <tr> <td style="border-right: 1px solid black; padding: 5px; vertical-align: top;">Y</td> <td style="border-right: 1px solid black; padding: 5px; vertical-align: top;">US, A 3,326,217 20 June 1967 KERR</td> <td style="padding: 5px; vertical-align: top;">1-11</td> </tr> <tr> <td style="border-right: 1px solid black; padding: 5px; vertical-align: top;">Y</td> <td style="border-right: 1px solid black; padding: 5px; vertical-align: top;">US, A 4,063,561 20 December 1977 MCKENNA</td> <td style="padding: 5px; vertical-align: top;">5</td> </tr> <tr> <td style="border-right: 1px solid black; padding: 5px; vertical-align: top;">X</td> <td style="border-right: 1px solid black; padding: 5px; vertical-align: top;">US, A 4,024,868 24 May 1977 WILLIAMS</td> <td style="padding: 5px; vertical-align: top;">1,4</td> </tr> <tr> <td style="border-right: 1px solid black; padding: 5px; vertical-align: top;">Y</td> <td style="border-right: 1px solid black; padding: 5px; vertical-align: top;">US, A 3,911,926 14 October 1975 PETERS</td> <td style="padding: 5px; vertical-align: top;">12-14</td> </tr> <tr> <td style="border-right: 1px solid black; padding: 5px; vertical-align: top;">Y</td> <td style="border-right: 1px solid black; padding: 5px; vertical-align: top;">US, A 4,245,638 20 January 1981 LEBECK ET AL</td> <td style="padding: 5px; vertical-align: top;">12-14</td> </tr> <tr> <td style="border-right: 1px solid black; padding: 5px; vertical-align: top;">Y</td> <td style="border-right: 1px solid black; padding: 5px; vertical-align: top;">US, A 2,406,393 27 August 1946 NEVGASS</td> <td style="padding: 5px; vertical-align: top;">6</td> </tr> <tr> <td style="border-right: 1px solid black; padding: 5px; vertical-align: top;">Y</td> <td style="border-right: 1px solid black; padding: 5px; vertical-align: top;">US, A 3,507,270 21 April 1970 FERRIER</td> <td style="padding: 5px; vertical-align: top;">7</td> </tr> <tr> <td style="border-right: 1px solid black; padding: 5px; vertical-align: top;">Y</td> <td style="border-right: 1px solid black; padding: 5px; vertical-align: top;">US, A 4,016,883 12 April 1977 WRIGHT</td> <td style="padding: 5px; vertical-align: top;">8</td> </tr> <tr> <td style="border-right: 1px solid black; padding: 5px; vertical-align: top;">Y</td> <td style="border-right: 1px solid black; padding: 5px; vertical-align: top;">DE, A 2,730,691 19 January 1978 KANAMOTO ET AL</td> <td style="padding: 5px; vertical-align: top;">12-14</td> </tr> </table>			Category <sup>6</sup>	Citation of Document, <sup>16</sup> with indication, where appropriate, of the relevant passages <sup>17</sup>	Relevant to Claim No. <sup>18</sup>	Y	US, A 1,352,978 14 September 1920 LANTIERI ET AL	1-4,8,9-11	Y	US, A 3,326,217 20 June 1967 KERR	1-11	Y	US, A 4,063,561 20 December 1977 MCKENNA	5	X	US, A 4,024,868 24 May 1977 WILLIAMS	1,4	Y	US, A 3,911,926 14 October 1975 PETERS	12-14	Y	US, A 4,245,638 20 January 1981 LEBECK ET AL	12-14	Y	US, A 2,406,393 27 August 1946 NEVGASS	6	Y	US, A 3,507,270 21 April 1970 FERRIER	7	Y	US, A 4,016,883 12 April 1977 WRIGHT	8	Y	DE, A 2,730,691 19 January 1978 KANAMOTO ET AL	12-14
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<div style="display: flex; justify-content: space-between;"> <div style="width: 45%;"> <p><sup>*</sup> Special categories of cited documents: <sup>15</sup></p> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier document but published on or after the international filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p> </div> <div style="width: 45%;"> <p>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step</p> <p>"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.</p> <p>"Z" document member of the same patent family</p> </div> </div>																																			
<b>IV. CERTIFICATION</b> <table style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 50%; border-bottom: 1px solid black; padding: 5px;">           Date of the Actual Completion of the International Search <sup>3</sup>   <div style="text-align: center;">23 May 1983</div> </td> <td style="width: 50%; border-bottom: 1px solid black; padding: 5px;">           Date of Mailing of this International Search Report <sup>2</sup>   <div style="text-align: center; font-size: 1.2em;">07 JUN 1983</div> </td> </tr> <tr> <td style="border-bottom: 1px solid black; padding: 5px;">           International Searching Authority <sup>1</sup>   <div style="text-align: center;">ISA/US</div> </td> <td style="border-bottom: 1px solid black; padding: 5px;">           Signature of Authorized Officer <sup>10</sup>  <div style="text-align: center;">              Michael H. Thaler           </div> </td> </tr> </table>			Date of the Actual Completion of the International Search <sup>3</sup>  <div style="text-align: center;">23 May 1983</div>	Date of Mailing of this International Search Report <sup>2</sup>  <div style="text-align: center; font-size: 1.2em;">07 JUN 1983</div>	International Searching Authority <sup>1</sup>  <div style="text-align: center;">ISA/US</div>	Signature of Authorized Officer <sup>10</sup> <div style="text-align: center;">              Michael H. Thaler           </div>																													
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